

AMENDMENTS TO THE DRAWINGS

The attached sheet of drawings includes changes to FIG. 12, as set forth in the Remarks portion of this paper.

Attachment: Replacement sheet containing FIG. 12

REMARKS

Claims 74-80, 82 and 83 are pending in this application. Claims 74-78 have been amended. Claims 75-78 have been amended only to correct typographical errors. Applicant reserves the right to pursue the original claims and other claims in this and other applications.

The drawings stand objected to. Specifically, "the . . . copper layer containing a copper oxide layer thereon; and a titanium-aluminum-copper nitrogen layer formed over at least an upper surface portion of said copper layer . . . must be shown or the feature(s) canceled from the claim(s)." (Office Action at 2) FIG. 12 has been amended to show the copper oxide layer 85 on the copper layer 26. The amendment merely clarifies what is already stated in the paragraph beginning at page 13, line 18 of the application, that layer 83 is a diffusion barrier and thus acts similarly to the diffusion barrier illustrated in FIG. 8. In addition, the paragraph beginning at page 13, line 18 has been amended to make reference to this copper oxide film layer 35. No new matter has been introduced by these amendments. Applicant respectfully requests that the objection be withdrawn.

Claims 74-78 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over Harada et al. (U.S. Patent No. 5,565,378) ("Harada") in view of Hsiao et al. (U.S. Patent No. 5,985,765) ("Hsiao"). This rejection is respectfully traversed.

Claim 74 recites a "copper bond pad" comprising *inter alia* "a dielectric layer formed over a substrate; a barrier layer formed over said dielectric layer" and "a copper layer formed over said barrier layer, said copper layer having only an upper surface implanted with titanium, said copper layer being primarily copper and having a thickness of about 500 Angstroms to about 20,000 Angstroms." The claim 74 copper bond pad also includes "an insulating layer over said copper layer."

Harada relates to a “passive state film . . . formed on a surface of a bonding pad.” (Abstract) Harada teaches that “silicon substrate 71 is immersed in solution continuously supplied with ozone.” (Abstract) In this manner, “[s]ince ozone is continuously supplied, it is possible to maintain the concentration of the dissolved ozone in the solution above a predetermined concentration.” (Abstract)

Hsiao relates to a “method for reducing bonding pad loss . . . using a capping layer when contact openings are etched to the bonding pads, while concurrently etching much deeper fuse openings to the substrate.” (Abstract) According to Hsiao, “[b]onding pads are used on the top surface of integrated circuit semiconductor chips to provide external electrical connections for I/Os and power.” (Abstract) Hsiao also teaches that the “invention uses a novel process in which a capping layer, having a low etch rate, is formed on the bonding pads to prevent overetching while the fuse openings are etched to the desired depth in the thicker insulating layers.” (Abstract)

Harada fails to disclose, teach or suggest “a copper layer formed over said barrier layer, said copper layer having only an upper surface implanted with titanium, said copper layer being primarily copper,” as independent claim 74 recites. In Harada, film 107 (which could arguably correspond to the “copper layer” of the claimed invention) is an “aluminum alloy film” that includes “aluminum and at least one material selected from the group consisting of copper (Cu), titanium (Ti), chromium (Cr), magnesium (Mg), scandium (Sc), yttrium (Y), zirconium (Zr), hafnium (Hf), vanadium (V), niobium (Nb), tantalum (Ta), molybdenum (Mo), tungsten (W) and palladium (Pd), which is added to the aluminum.” (Col. 6, lines 54-60) Thus, the aluminum alloy film 107 of Harada is primarily aluminum and is not a “copper layer” that is “primarily copper” as recited in the claimed invention. Harada is also silent about a “copper layer having only an upper surface implanted with titanium.” Although layer 107 of Harada contains “aluminum and at least one material selected

from the group consisting of copper (Cu), titanium (Ti)..." (Col. 6, lines 54-56), this does not disclose implantation of titanium on only the upper surface of the layer, but suggests that the titanium, if included, is distributed equally throughout the aluminum layer.

Hsiao also fails to disclose, teach or suggest all limitations of claim 74. Hsiao is silent about a "copper layer formed over said barrier layer, said copper layer having only an upper surface implanted with titanium, said copper layer being primarily copper," as independent claim 74 recites. Hsiao teaches that layer 18 (which could arguably correspond to the "copper layer" of the claimed invention) is "preferably a multilayer composed of a titanium nitride (TiN) layer 18A, an AlCu layer 18B, and a second TiN layer 18C" (Col. 4, lines 62-64) Thus, the cited combination fails to disclose, teach or suggest a "copper layer formed over said barrier layer, said copper layer having only an upper surface implanted with titanium, said copper layer being primarily copper," as is recited in claim 74.

Therefore, Harada and Hsiao, whether considered alone or in combination, do not disclose, teach or suggest all limitations of claim 74. Accordingly, claim 74 is believed to be allowable over the cited combination. Claims 75-78 depend from claim 74 and are allowable along with claim 74. Withdrawal of the rejection of claims 74-78 is respectfully requested and allowance of the claims is solicited.

Claims 79, 80, 82 and 83 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over Jang et al. (U.S. Patent No. 6,423,625) ("Jang") in view of Harada and in view of Mahulikar et al. (U.S. Patent No. 5,320,689) ("Mahulikar"). This rejection is respectfully traversed.

Claim 79 recites an “interconnect structure for a semiconductor die” comprising “a conductive bond pad containing a copper layer, said copper layer containing a copper oxide layer thereon.” Claim 79 further recites “a titanium-aluminum-copper-nitrogen layer formed over at least an upper surface portion of said copper layer.”

Jang relates to a method of improving the bondability between gold wires and copper bonding pads. (Abstract) Jang teaches that, to prevent copper oxidation, “with the methods of the present invention, Al or AlCu as a glue and protection layer is implemented on Cu bonding pads for successful Au wiring.” (Abstract)

Harada relates to a “passive state film . . . formed on a surface of a bonding pad.” (Abstract) Harada teaches that “silicon substrate 71 is immersed in solution continuously supplied with ozone.” (Abstract) In this manner, “[s]ince ozone is continuously supplied, it is possible to maintain the concentration of the dissolved ozone in the solution above a predetermined concentration.” (Abstract)

Mahulikar relates to “a composite copper alloy having a copper alloy core and a modified surface layer containing a nitride or carbide film.” (Abstract) According to Mahulikar, “the modified surface layer may contain a carbo-nitride film” and “[t]he alloy is formed by reacting a copper alloy with nitrogen, carbon or a nitrogen/carbon mixture at elevated temperatures.” (Abstract)

Applicant respectfully submits that Jang, Harada and Mahulikar are not properly combined for the purpose of this obviousness rejection. There would have been no motivation to combine the references for the purpose of teaching or suggesting the titanium-aluminum-copper-nitrogen layer absent the impermissible use of hindsight using the claims of the present application as a roadmap. The mere fact that

references can be combined or modified is not sufficient to establish *prima facie* obviousness, the prior art must also suggest the desirability of the combination, which is not present here. M.P.E.P. § 2143.01 (citing In re Mills, 916 F.2d 680, 16 U.S.P.Q.2d 1430 (Fed. Cir. 1990) (emphasis added)).

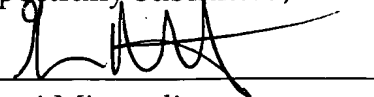
Applicant respectfully submits that one skilled in the art would not have been motivated to combine the references in the manner suggested by the Office Action. The Al-Cu layer of Jang acts as a protective layer over a copper bond pad layer. The Al-Ti layer of Harada is cited by the Office Action as the “copper layer” of claim 74 (in the previous rejection). It is unclear to Applicant how the “copper layer” can also be “formed over ... said copper layer.” The only apparent relevance of Harada to claim 79 is its mention of titanium. The Cu-N layer of Mahulikar acts as a barrier layer on the surface of an iron- or nickel-based alloy, thereby providing improved tribological (i.e. friction and wear) and mechanical properties.

It would not have been obvious from these three disparate references to combine these four elements into the single Ti-Al-Cu-N layer provided over the copper layer in claim 79. Additionally, these references each disclose merely two of the four elements combined in the claim. None of these references disclose or suggest combining three, let alone all four, of the elements into the same layer. Because of this lack of motivation to combine, claim 79 is patentable over the cited combination. Therefore, claims 80 and 82-83 which depend from claim 79 should be allowable as well. Withdrawal of the rejection and allowance of claims 79-80 and 82-83 is respectfully requested.

In view of the above amendment, applicant believes the pending application is in condition for allowance.

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Respectfully submitted,

By 

Gianni Minutoli

Registration No.: 41,198

Jennifer M. McCue

Registration No.: 55,440

DICKSTEIN SHAPIRO MORIN &
OSHINSKY LLP

2101 L Street NW

Washington, DC 20037-1526

(202) 785-9700

Attorneys for Applicant